REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	24 JUNE 02	FINAL REPORT 1 OCT 98 - 30 SEPT 99

4. TITLE AND SUBTITLE Material and Acoustical Studies of Elastic Protein-Based Polymers Engineered for Selected Acoustical and Non-Acoustical Characteristics

5. FUNDING NUMBERS

N00014-99-WX-20344

6. AUTHOR(S)

Jack Y. Dea and Lev Sheiba

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

SPAWAR SYSTEMS CENTER
Code 271
53560 Hull Street
San Diego, CA 92152-5001

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Distribution Unlimited

13. ABSTRACT *(Maximum 200 words)*

Elastic protein-based polymers have been synthesized. These are solid materials having been cross-linked by gamma-ray irradiation. Three (3) of these samples have been measured. The results show that their elastic properties are different from traditional rubbers and polyurethanes. Typical absorbent materials have loss factors that rise with increase in frequency and a shear modulus that is relatively flat with frequency. On the other hand, the protein-based polymers have large loss factors at low frequencies, have loss factor that decrease with frequency, and have shear modulus that sharply increase at the high frequency end. These results demonstrate that these new materials hold great promise in their application as materials for broad band anechoic coatings for ships and submarines.

14. SUBJECT TERMS	15. NUMBER OF PAGES
biopolymer , polymer, elastic polymer, protein-based polymer, engineered polymer, acoustical polymer, anechoic coating	3
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassfied	Unclassfied	Unclassfied	UL

FINAL REPORT

GRANT # : N00014-99-WX-20344

PRINCIPAL INVESTIGATOR: Dr. Jack Y. Dea

INSTITUTION: SPAWAR SYSTEMS CENTER

GRANT TITLE: Material and Acoustical Studies of Elastic Protein-Based Polymers Engineered for Selected Acoustical and Non-Acoustical Characteristics

OBJECTIVE: Measure and evaluate the elastic and acoustical properties of elastic protein-based polymers engineered for selected acoustical and non-acoustical characteristics.

APPROACH: Elastic protein-based polymers are produced by Bioelastics, Inc. These polymers are engineered to have low frequency acoustical absorption. These polymers are send to SPAWAR SYSTEMS CENTER for analysis on elastic properties.

ACCOMPLISHMENTS: Elastic protein-based polymers have been synthesized by Professor Urry and his group to provide selected acoustical absorption. These polymers are solid materials, having been cross-linked by gamma-ray irradiation. Three (3) of these polymers (names I, II and III) have been measured in Dr. Lev Sheiba's experimental set-up. Dr. Sheiba's system can measure all the elastic parameters of a small piece of material without the necessity of large samples and without the incursion of large errors. The measurement results showed that all 3 polymers, especially polymers II and III, have excellent acoustical absorption characteristics as shown in their loss factor plots. Their characteristics are different from those of traditional rubbers and polyurethanes in the designated frequency range of 200 Hz to 7 kHz. These results demonstrate that these new materials hold great promise in their application as materials for broad band anechoic coatings for submarine stealth technology.

CONCLUSIONS: The shear modulus, bulk modulus and loss factor at various temperatures have been experimentally determined for 3 protein-based materials, Polymer I, Polymer II, and Polymer III. These samples were synthesized in Professor Urry's laboratory. The shear modulus and loss factors for Polymers I, II and III are significantly different from traditional elastic materials such as polyurethane (PAN10), and natural rubber. Typical absorbent materials, natural rubber and PAN10 (polyurethane), have loss factors that rise with frequency, loss factors of around 0.2 to 0.3 and relatively flat shear modulus with frequency. On the other hand, the loss factor of the protein-based elastic polymers have large loss factors at low frequencies (around 1.0), loss factors that decrease at with frequency at the high frequency end, and shear modulus that sharply increase at the high frequency end.

SIGNIFICANCE: According to Dr. Sheiba, these characteristics of the elastic protein-based polymers are EXACTLY the qualities needed for stealth coatings for submarines. The high loss factor at low frequencies is quite clearly the characteristics needed for low frequency sonar absorption. The behavior of the loss factor and the

shear modulus at the higher frequencies insure good broadband sonar absorption. In fact, Dr. Sheiba has always claimed that a loss factor that decreases with frequency would be the ideal characteristic for broad band absorption. However, typical elastic materials, such as polyurethane and natural rubber, do not show these characteristics. Our elastic protein-based polymers are really quite unique with respect to these desired characteristics.

PUBLICATION AND ABSTRACTS:

1. Urry, D.W., Hugel, T., Seitz, M. Gaub, H., Sheiba, L., Dea, J., Xu, J., Parker, T. (2001) Elastin: A representative ideal protein elastomer. Abstract presented to Royal Society Meeting, London, May 16-17.